

Intel® 3000 and 3010 Chipset Memory Controller Hub (MCH)

Thermal/Mechanical Design Guide

August 2006



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Revision History

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1 Introduction

As the complexity of computer systems increases, so do the power dissipation requirements. Care must be taken to ensure that the additional power is properly dissipated. Typical methods to improve heat dissipation include selective use of ducting, and/or passive heatsinks.

The goals of this document are to:

- Outline the thermal and mechanical operating limits and specifications for the Intel® 3000 and 3010 chipsets memory controller hub (MCH).
- Describe a reference thermal solution that meets the specification of the Intel 3000 and 3010 chipsets MCH.

Properly designed thermal solutions provide adequate cooling to maintain the Intel 3000 and 3010 chipsets MCH die temperatures at or below thermal specifications. This is accomplished by providing a low local-ambient temperature, ensuring adequate local airflow, and minimizing the die to local-ambient thermal resistance. By maintaining the Intel 3000 and 3010 chipset MCH die temperature at or below the specified limits, a system designer can ensure the proper functionality, performance, and reliability of the chipset. Operation outside the functional limits can degrade system performance and may cause permanent changes in the operating characteristics of the component.

The simplest and most cost effective method to improve the inherent system cooling characteristics is through careful chassis design and placement of fans, vents, and ducts. When additional cooling is required, component thermal solutions may be implemented in conjunction with system thermal solutions. The size of the fan or heatsink can be varied to balance size and space constraints with acoustic noise.

This document addresses thermal design and specifications for the Intel 3000 and 3010 chipsets MCH components only. For thermal design information on other chipset components, refer to the respective component datasheet. For the PXH, refer to the *Intel® 6700PXH 64-bit PCI Hub/6702PXH 64-bit PCI Hub (PXH/PXH-V) Thermal/Mechanical Design Guidelines*. For the ICH7, refer to the *Intel® I/O Controller Hub7 (ICH7) Thermal Design Guidelines*.

Note: Unless otherwise specified, the term “MCH” refers to the Intel 3000 and 3010 chipsets MCH.

1.1 Definition of Terms

BGA	Ball grid array. A package type, defined by a resin-fiber substrate, onto which a die is mounted, bonded and encapsulated in molding compound. The primary electrical interface is an array of solder balls attached to the substrate opposite the die and molding compound.
BLT	Bond line thickness. Final settled thickness of the thermal interface material after installation of heatsink.
MCH	Memory controller hub. The chipset component contains the processor interface, the memory interface, the PCI Express* interface and the DMI interface.



ICH	I/O controller hub. The chipset component contains the MCH interface, the SATA interface, the USB interface, the IDE interface, the LPC interface etc.
PXH	Intel 6700PXH 64-bit PCI Hub. The chipset component performs PCI bridging functions between the PCI Express interface and the PCI Bus. It contains two PCI bus interfaces that can be independently configured to operate in PCI (33 or 66 MHz) or PCI-X* mode 1 (66, 100 or 133 MHz), for either 32 or 64 bit PCI devices.
PXH-V	Intel 6702PXH 64-bit PCI Hub. The chipset component performs PCI bridging functions between the PCI Express interface and the PCI Bus. It contains one PCI bus interface that can be configured to operate in PCI (33 or 66 MHz) or PCI-X mode 1 (66, 100 or 133 MHz).
T _{case_max}	Maximum die or IHS temperature allowed. This temperature is measured at the geometric center of the top of the package die or IHS.
T _{case_min}	Minimum die or IHS temperature allowed. This temperature is measured at the geometric center of the top of the package die or IHS.
TDP	Thermal design power. Thermal solutions should be designed to dissipate this target power level. TDP is not the maximum power that the chipset can dissipate.

1.2 Reference Documents

The reader of this specification should also be familiar with material and concepts presented in the following documents:

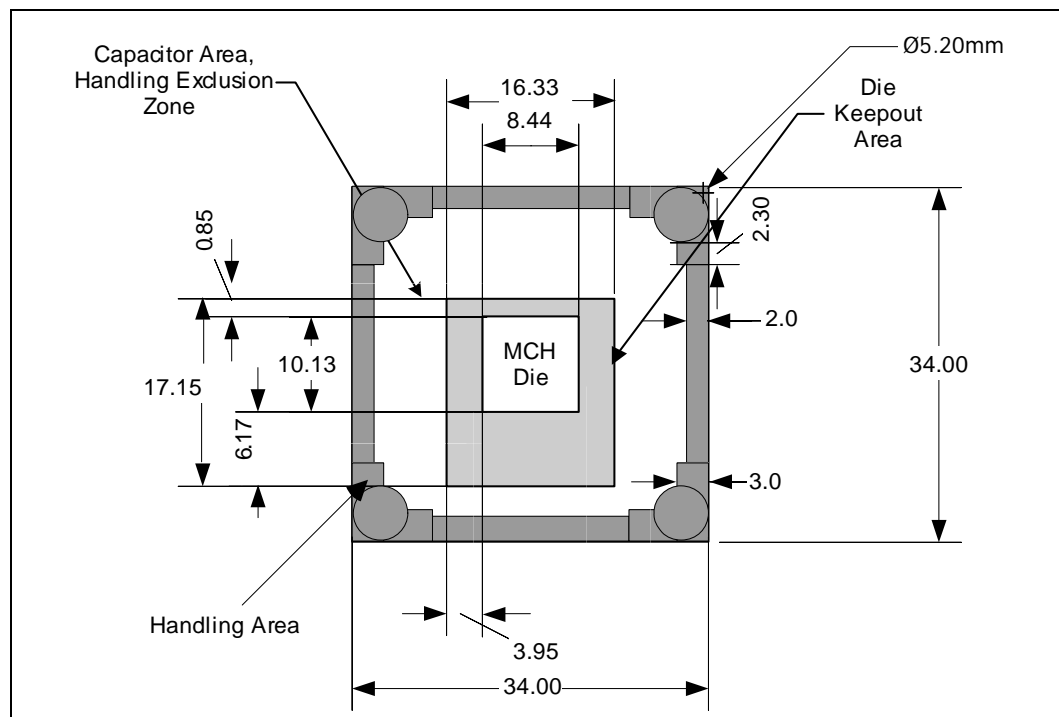
Document Title	Document Number / Location
Intel® I/O Controller Hub 7 (ICH7) Thermal Design Guidelines	www.developer.intel.com
Intel® I/O Controller Hub 7 (ICH7) Family Datasheet	www.developer.intel.com
Intel® 3000 and 3010 Chipset Memory Controller Hub (MCH) Datasheet	www.developer.intel.com
Intel® Pentium® D Processor 900Δ Sequence and Intel® Pentium® Processor Extreme Edition 955Δ, 965Δ Datasheet	www.developer.intel.com
Intel® Pentium® 4 Processor 6x1Δ Sequence Datasheet	www.developer.intel.com
Intel® Pentium® D Processor 800Δ Sequence Datasheet	www.developer.intel.com
Dual-Core Intel® Xeon® Processor 3000 Series Datasheet	www.developer.intel.com
Dual-Core Intel® Xeon® Processor 3000 Series Specification Update	www.developer.intel.com
BGA/OLGA Assembly Development Guide	Contact your Intel Field Sales Representative
Various system thermal design suggestions	http://www.formfactors.org



2 Packaging Technology

The Intel 3000 and 3010 chipsets consists of three individual components: the MCH, the ICH7 and the PXH. The Intel 3000 and 3010 chipsets MCH components use a 34 mm squared, 6-layer flip chip ball grid array (FC-BGA) package (see [Figure 2-1](#), [Figure 2-2](#) and [Figure 2-3](#)). For information on the PXH package, refer to the *Intel® 6700PXH 64-bit PCI Hub/6702PXH 64-bit PCI Hub (PXH/PXH-V) Thermal/Mechanical Design Guidelines*. For information on the ICH7 package, refer to the *Intel® I/O Controller Hub7 (ICH7) Thermal Design Guidelines*.

Figure 2-1. MCH Package Dimensions (Top View)



Note: All Dimensions are in Millimeter.

Figure 1 is a dimensional drawing of a BGA package. It shows a side view of the package with various dimensions and labels. Key dimensions include: 2.355 ± 0.082 mm (total height), 1.92 ± 0.078 mm (height to decoupling cap), 0.84 ± 0.05 mm (decoupling cap height), 0.7 mm Max (height to seating plane), and 0.435 ± 0.025 mm (height to seating plane). Labels include: Substrate, Decoupling Cap, Die, Seating Plane, and See note 4. Surface texture symbols are shown on the substrate and decoupling cap. A datum -C- is indicated at the bottom right, with a note 'See note 1.' pointing to it.

Figure 1: Plan view of the test specimen showing dimensions and grid layout. The specimen is rectangular with a width of 0.800 Min. and a height of 0.436 REF. The grid is labeled with letters A through Z on the left and numbers 1 through 43 on the bottom. The bottom edge has a dimension of 0.942. The top edge has a dimension of 0.436 REF. The left edge has a dimension of 0.436 REF. The right edge has a dimension of 0.436 REF.

NOTES:

1. All dimensions are in millimeters.
2. All dimensions and tolerances conform to ANSI Y14.5M-1994.



2.1 Package Mechanical Requirements

The Intel 3000 and 3010 chipsets MCH package has an exposed bare die which is capable of sustaining a maximum static normal load of 10-lbf. The package is NOT capable of sustaining a dynamic or static compressive load applied to any edge of the bare die. These mechanical load limits must not be exceeded during heatsink installation, mechanical stress testing, standard shipping conditions and/or any other use condition.

Notes:

1. The heatsink attach solutions must not include continuous stress onto the chipset package with the exception of a uniform load to maintain the heatsink-to-package thermal interface.
2. These specifications apply to uniform compressive loading in a direction perpendicular to the bare die top surface.
3. These specifications are based on limited testing for design characterization. Loading limits are for the package only.

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3 Thermal Specifications

3.1 Thermal Design Power (TDP)

Analysis indicates that real applications are unlikely to cause the MCH component to consume maximum power dissipation for sustained time periods. Therefore, in order to arrive at a more realistic power level for thermal design purposes, Intel characterizes power consumption based on known platform benchmark applications. The resulting power consumption is referred to as the Thermal Design Power (TDP). TDP is the target power level that the thermal solutions should be designed to. TDP is not the maximum power that the chipset can dissipate.

For TDP specifications, see [Table 3-1](#) and [Table 3-1](#) for the Intel 3000 and 3010 chipsets MCH. FC-BGA packages have poor heat transfer capability into the board and have minimal thermal capability without a thermal solution. Intel recommends that system designers plan for a heatsink when using the Intel 3000 and 3010 chipsets.

3.2 Die Case Temperature

To ensure proper operation and reliability of the Intel 3000 and 3010 chipsets MCH, the die temperatures must be at or between the maximum/minimum operating temperature ranges as specified in [Table 3-1](#) and [Table 3-2](#). System and/or component level thermal solutions are required to maintain these temperature specifications. Refer to [Chapter 5](#) for guidelines on accurately measuring package die temperatures.

Table 3-1. Intel 3000 Chipset MCH Thermal Specifications

Parameter	Value	Notes
T _{case_max}	105 °C	
T _{case_min}	5 °C	
TDP _{dual channel}	10.6 W	DDR2-533
TDP _{dual channel}	12.7 W	DDR2-667

Note: These specifications are based on post silicon power measurement.

Table 3-2. Intel 3010 Chipset MCH Thermal Specifications

Parameter	Value	Notes
T _{case_max}	105 °C	
T _{case_min}	5 °C	
TDP _{dual channel}	11.5 W	DDR2-533
TDP _{dual channel}	13.6 W	DDR2-667

Note: These specifications are based on silicon characterization; however, they may be updated as further data becomes available.

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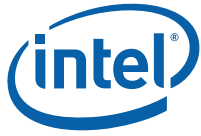




4 Thermal Simulation

Intel provides thermal simulation models of the Intel 3000 and 3010 chipsets MCH and associated user's guides to aid system designers in simulating, analyzing, and optimizing their thermal solutions in an integrated, system-level environment. The models are for use with the commercially available Computational Fluid Dynamics (CFD)-based thermal analysis tool FLOTHERM* (version 5.1 or higher) by Flomerics, Inc. Contact your Intel field sales representative to order the thermal models and user's guides.







5 Thermal Metrology

The system designer must make temperature measurements to accurately determine the thermal performance of the system. Intel has established guidelines for proper techniques to measure the MCH die temperatures. [Section 5.1](#) provides guidelines on how to accurately measure the MCH die temperatures. [Section 5.2](#) contains information on running an application program that will emulate anticipated maximum thermal design power. The flowchart in [Figure 5-1](#) offers useful guidelines for thermal performance and evaluation.

5.1 Die Temperature Measurements

To ensure functionality and reliability, the T_{case} of the MCH must be maintained at or between the maximum/minimum operating range of the temperature specification as noted in [Table 3-1](#) and [Table 3-2](#). The surface temperature at the geometric center of the die corresponds to T_{case} . Measuring T_{case} requires special care to ensure an accurate temperature measurement.

Temperature differences between the temperature of a surface and the surrounding local ambient air can introduce errors in the measurements. The measurement errors could be due to a poor thermal contact between the thermocouple junction and the surface of the package, heat loss by radiation and/or convection, conduction through thermocouple leads, and/or contact between the thermocouple cement and the heatsink base (if a heatsink is used). For maximize measurement accuracy, only the 0° thermocouple attach approach is recommended.

5.1.1 Zero Degree Angle Attach Methodology

1. Mill a 3.3 mm (0.13 in.) diameter and 1.5 mm (0.06 in.) deep hole centered on the bottom of the heatsink base.
2. Mill a 1.3 mm (0.05 in.) wide and 0.5 mm (0.02 in.) deep slot from the centered hole to one edge of the heatsink. The slot should be parallel to the heatsink fins (see [Figure 5-25-2](#)).
3. Attach thermal interface material (TIM) to the bottom of the heatsink base.
4. Cut out portions of the TIM to make room for the thermocouple wire and bead. The cutouts should match the slot and hole milled into the heatsink base.
5. Attach a 36 gauge or smaller calibrated K-type thermocouple bead or junction to the center of the top surface of the die using a high thermal conductivity cement. During this step, ensure no contact is present between the thermocouple cement and the heatsink base because any contact will affect the thermocouple reading. **It is critical that the thermocouple bead makes contact with the die** (see [Figure 5-3](#)).
6. Attach heatsink assembly to the MCH and route thermocouple wires out through the milled slot.

Figure 5-1. Thermal Solution Decision Flowchart

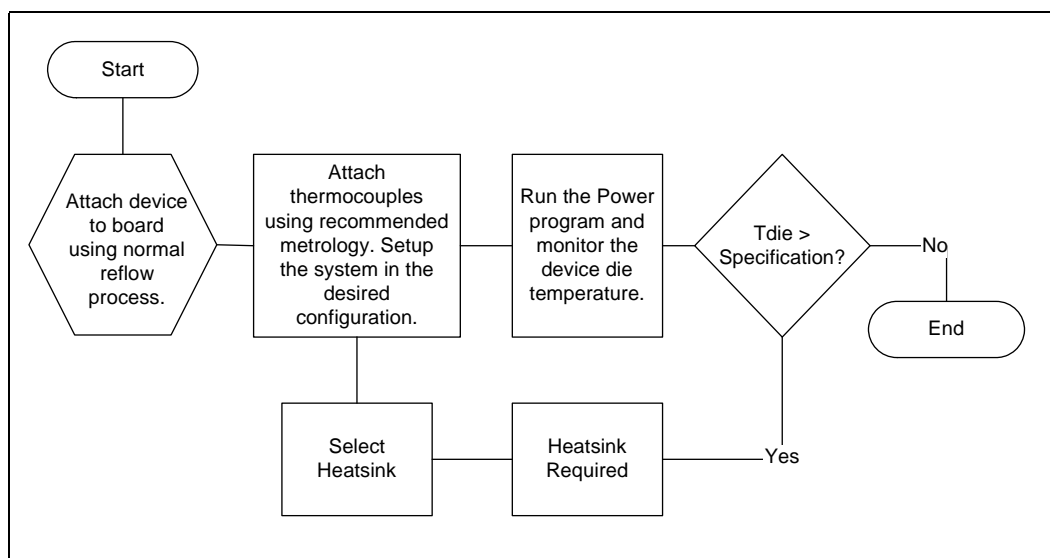
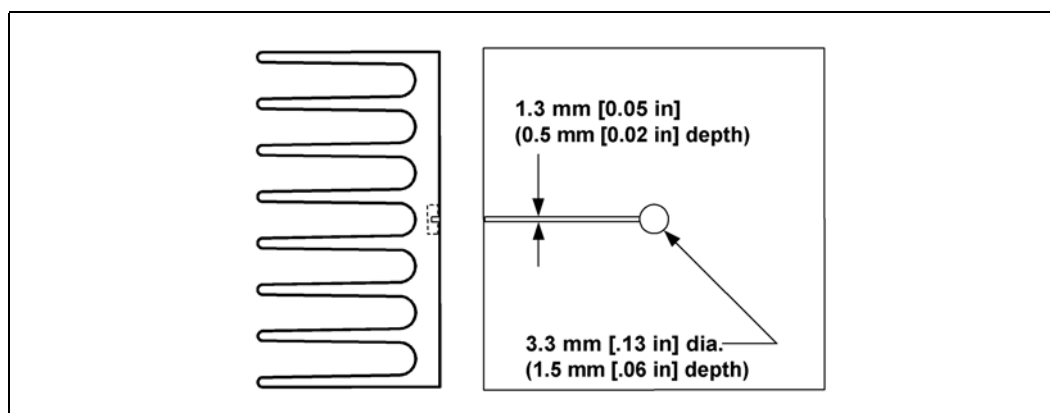
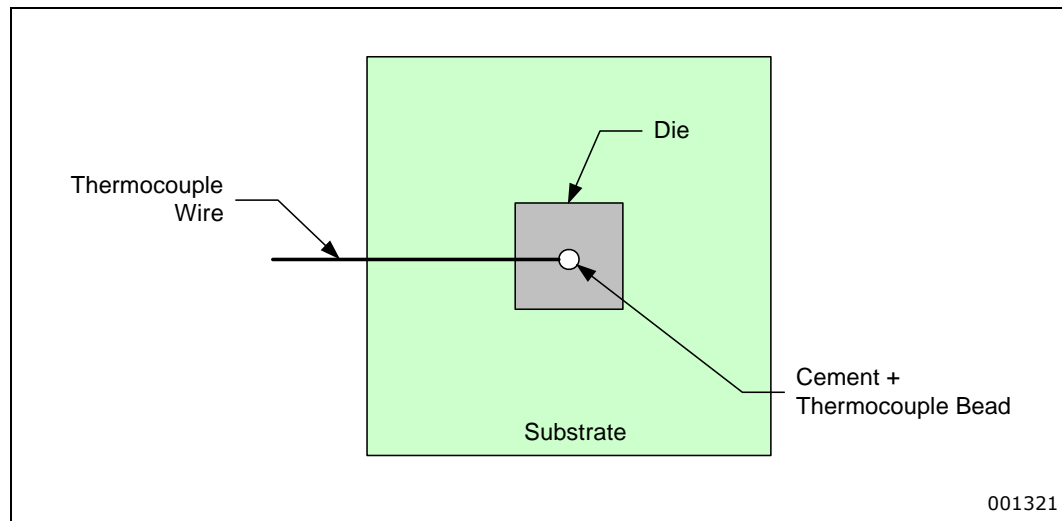


Figure 5-2. Zero Degree Angle Attach Heatsink Modifications



Note: Not to scale.

Figure 5-3. Zero Degree Angle Attach Methodology (Top View)



Note: Not to scale.

5.2 Power Simulation Software

The power simulation software is a utility designed to dissipate the thermal design power on a Intel 3000 and 3010 chipsets MCH when used in conjunction with the Dual-Core Intel® Xeon® processor 3000 series (1066 MHz). The combination of the above mentioned processor(s) and the higher bandwidth capability of the Intel 3000 and 3010 chipsets enable higher levels of system performance. To assess the thermal performance of the chipset MCH thermal solution under “worst-case realistic application” conditions, Intel is developing a software utility that operates the chipset at near worst-case thermal power dissipation.

The power simulation software being developed should only be used to test thermal solutions at or near the thermal design power. [Figure 5-1](#) shows a decision flowchart for determining thermal solution needs. Real world applications may exceed the thermal design power limit for transient time periods. For power supply current requirements under these transient conditions, please refer to each component's datasheet for the ICC (Max Power Supply Current) specification. Contact your Intel field sales representative to order the power utility and user's guides.

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6 Reference Thermal Solution

Intel has developed a reference thermal solution to meet the cooling needs of the Intel 3000 and 3010 chipsets MCH under operating environments and specifications defined in this document. This chapter describes the overall requirements for the Plastic Wave Soldering Heatsink (PWSH) reference thermal solution including critical-to-function dimensions, operating environment, and validation criteria. Other chipset components may or may not need attached thermal solutions, depending on your specific system local-ambient operating conditions. For information on the PXH/PXH-V, refer to thermal specification in the *Intel® 6700PXH 64-bit PCI Hub/6702PXH 64-bit PCI Hub (PXH/PXH-V) Thermal/Mechanical Design Guidelines*. For information on the ICH7, refer to thermal specification in the *Intel® I/O Controller Hub 7 (ICH7) Thermal Design Guidelines*.

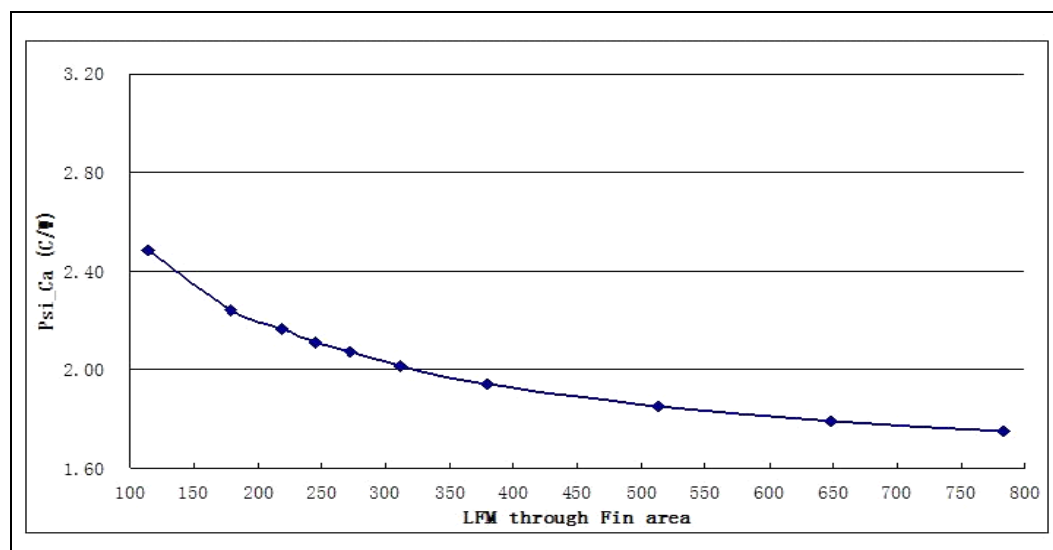
6.1 Operating Environment

The reference thermal solution was designed assuming a maximum local-ambient temperature of 55 °C. The minimum recommended airflow velocity through the cross-section of the heatsink fins is 350 linear feet per minute (lfm) for 1U system and 450 linear feet per minute (lfm) for 2U+ system. The approaching airflow temperature is assumed to be equal to the local-ambient temperature. The thermal designer must carefully select the location to measure airflow to obtain an accurate estimate. These local-ambient conditions are based on a 35 °C external-ambient temperature at sea level. (External-ambient refers to the environment external to the system.)

6.2 Heatsink Performance

Figure 6-1 depicts the measured thermal performance of the reference thermal solution versus approach air velocity. Since this data was measured at sea level, a correction factor would be required to estimate thermal performance at other altitudes.

Figure 6-1. Plastic Wave Soldering Heatsink Measured Thermal Performance versus Approach Velocity



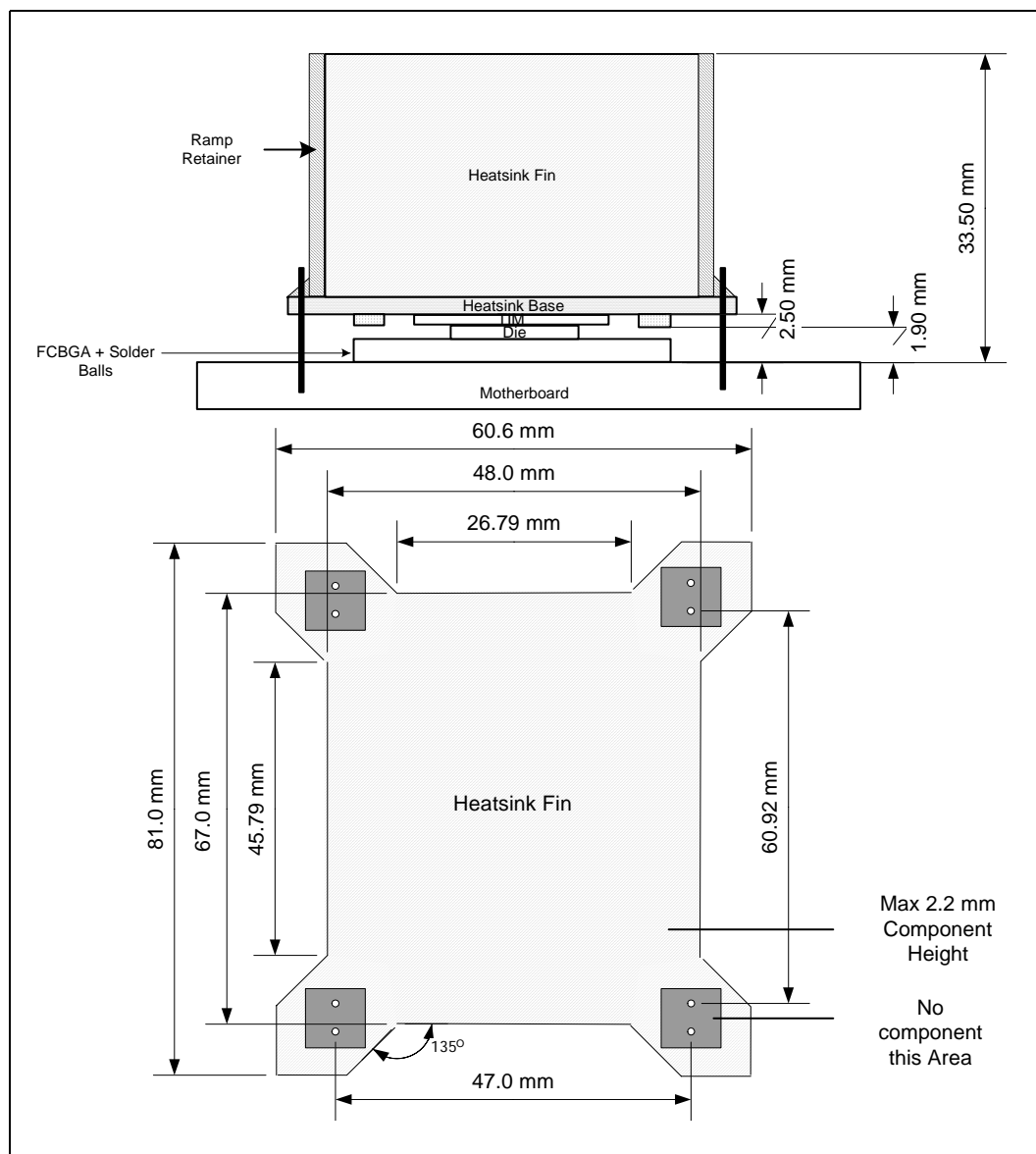
Heatsink test result is based on End of Life TIM performance, for worst case Heatsink performance with End of Life TIM, need to add +1.0C/W offset to Psi_{ca}.

6.3 Mechanical Design Envelope

While each design may have unique mechanical volume and height restrictions or implementation requirements, the height, width, and depth constraints typically placed on the Intel 3000 and 3010 chipsets MCH thermal solution are shown in Figure 6-2.

When using heatsinks that extend beyond the chipset MCH reference heatsink envelope shown in Figure 6-2, any motherboard components placed between the heatsink and motherboard cannot exceed 2.19 mm (0.09 in.) in height.

Figure 6-2. Plastic Wave Soldering Heatsink Volumetric Envelope for the Chipset MCH



6.4 Board-Level Components Keepout Dimensions

The location of hole patterns and keepout zones for the reference thermal solution are shown in [Figure 6-3](#) and [Figure 6-4](#).

6.5 Plastic Wave Soldering Heatsink Thermal Solution Assembly

The reference thermal solution for the chipset MCH is a passive extruded heatsink with thermal interface. It is attached using a clip with each end hooked through an anchor soldered to the board. [Figure 6-5](#) shows the reference thermal solution assembly and associated components.

Full mechanical drawings of the thermal solution assembly and the heatsink clip are provided in [Appendix B](#). [Appendix A](#) contains vendor information for each thermal solution component.

Figure 6-3. Plastic Wave Soldering Heatsink Board Component Keepout

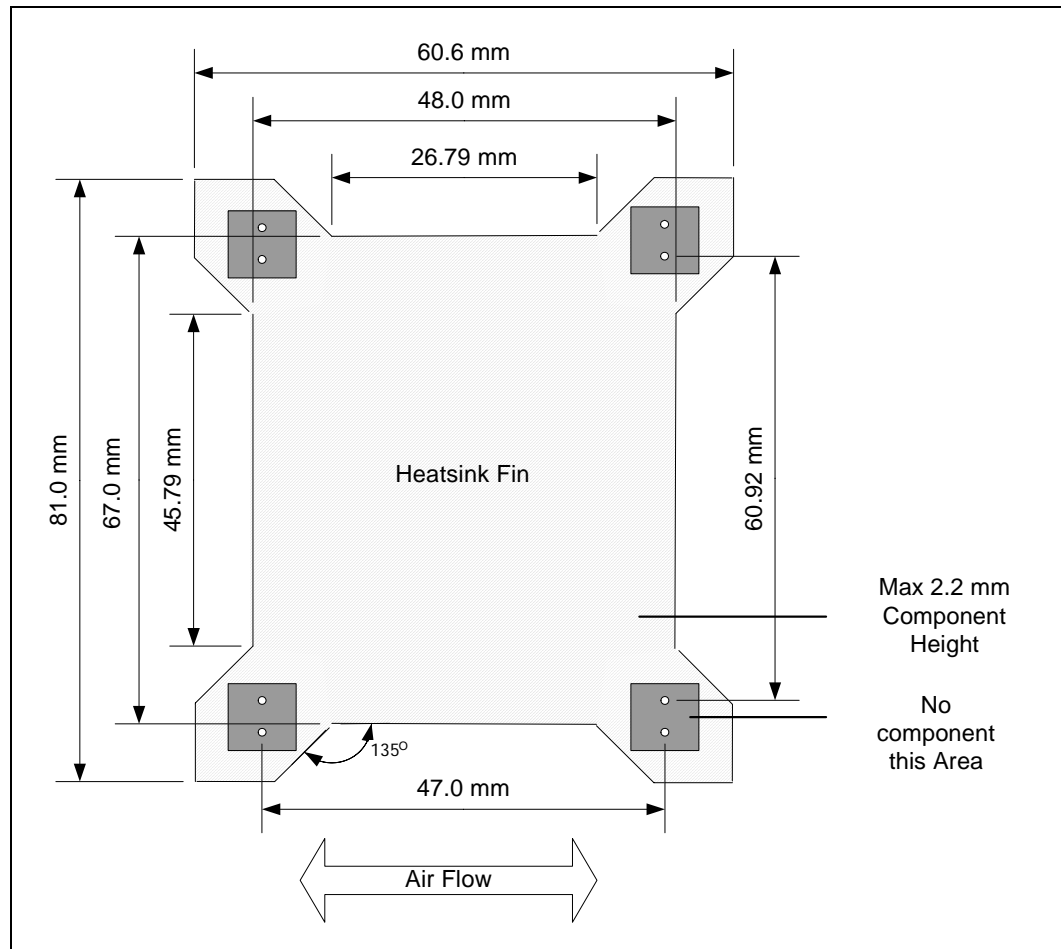
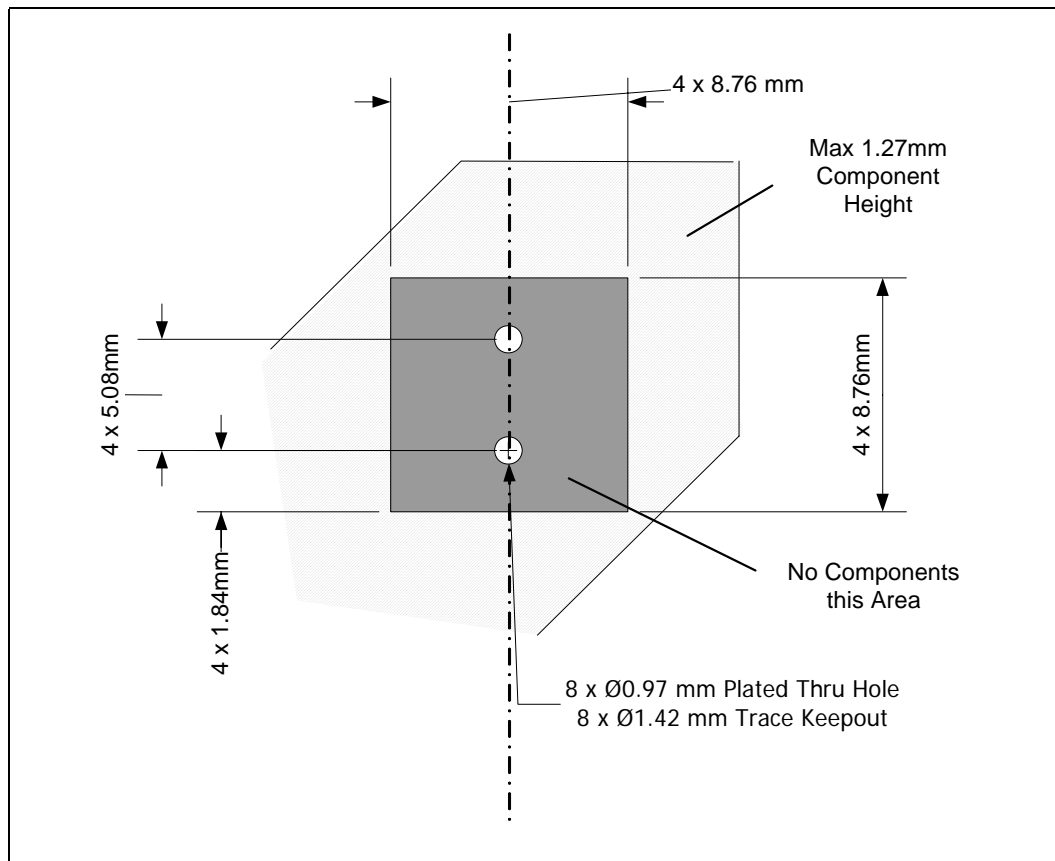
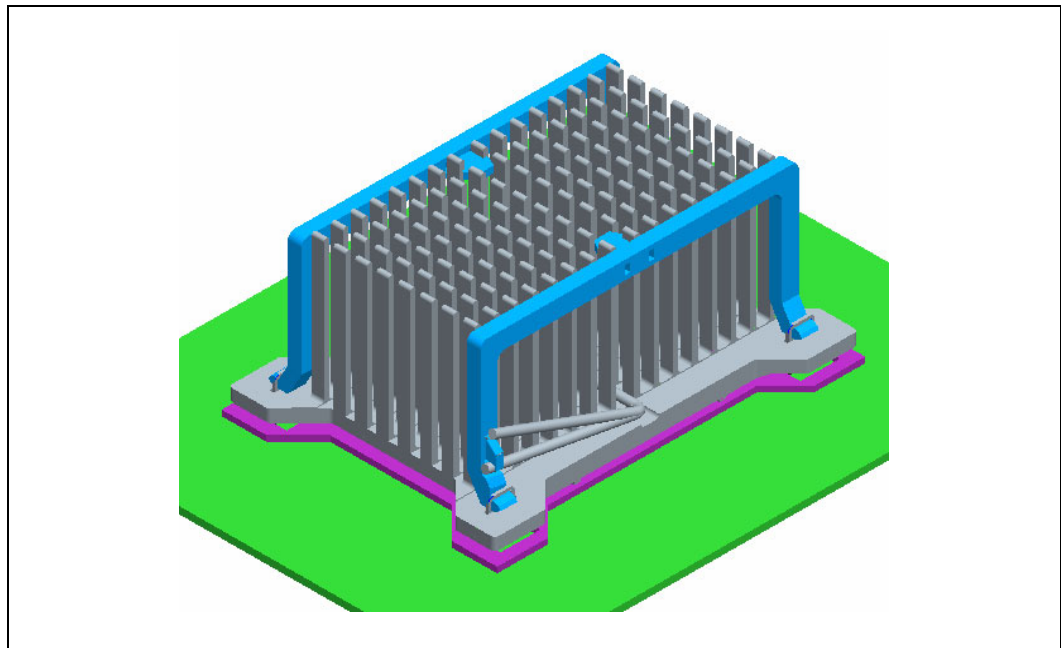


Figure 6-4. Retention Mechanism Component Keepout Zones



6.5.1 Heatsink Orientation

Since this solution is based on a unidirectional heatsink, mean airflow direction must be aligned with the direction of the heatsink fins.

Figure 6-5. Plastic Wave Soldering Heatsink Assembly

6.5.2 Extruded Heatsink Profiles

The reference thermal solution uses an extruded heatsink for cooling the chipset MCH. [Figure 6-6](#) shows the heatsink profile. [Appendix A](#) lists a supplier for this extruded heatsink. Other heatsinks with similar dimensions and increased thermal performance may be available. Full mechanical drawing of this heatsink is provided in [Appendix B](#).

6.5.3 Mechanical Interface Material

There is no mechanical interface material associated with this reference solution.

6.5.4 Thermal Interface Material

A TIM provides improved conductivity between the die and heatsink. The reference thermal solution uses Chomerics T-710, 0.127 mm (0.005 in.) thick, 15 mm x 15 mm (0.60 in. x 0.60 in.) square.

Note: Unflowed or “dry” Chomerics T-710 has a material thickness of 0.005 inch. The flowed or “wet” Chomerics T-710 has a material thickness of ~0.0025 inch after it reaches its phase change temperature.

6.5.4.1 Effect of Pressure on TIM Performance

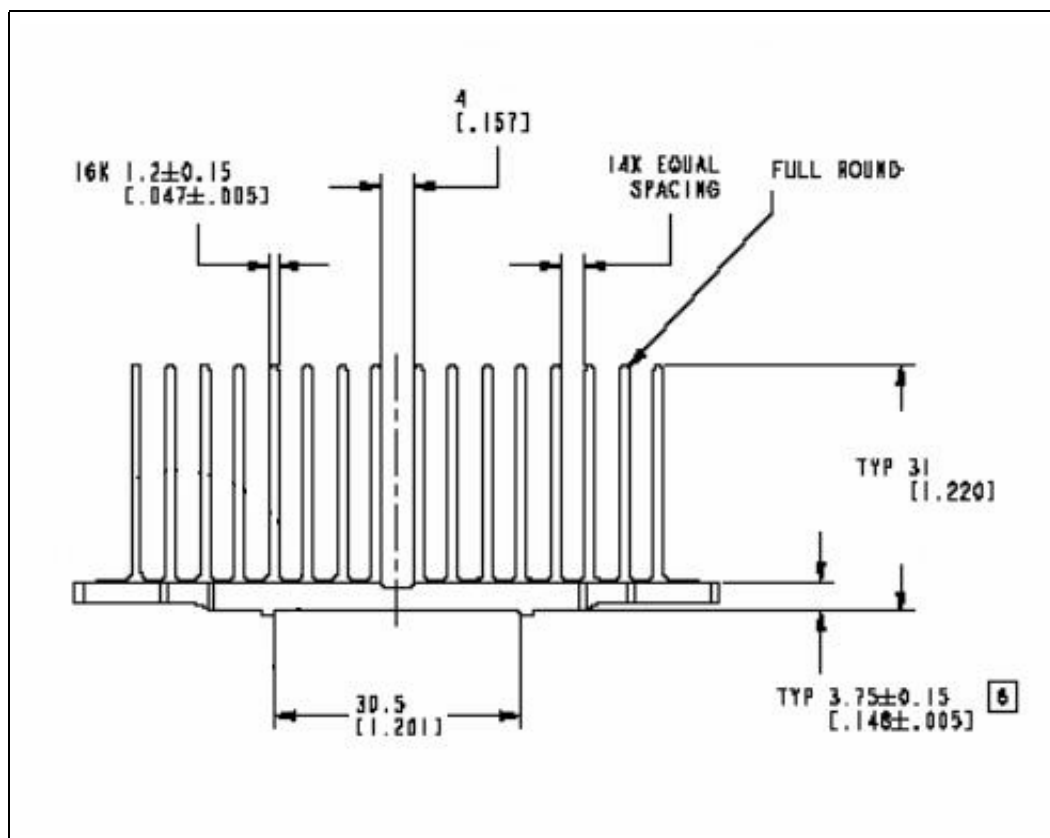
As mechanical pressure increases on the TIM, the thermal resistance of the TIM decreases. This phenomenon is due to the decrease of the bond line thickness (BLT). BLT is the final settled thickness of the thermal interface material after installation of heatsink. The effect of pressure on the thermal resistance of the Chomerics T-710 TIM is shown in [Table 6-1](#). The heatsink clip provides enough pressure for the TIM to achieve a thermal conductivity of 0.17 °C inch²/W.

Table 6-1. Chomerics* T-710 TIM Performance as a Function of Attach Pressure

Pressure (psi)	Thermal Resistance ($^{\circ}\text{C} \times \text{in}^2/\text{W}$)
5	0.37
10	0.30
20	0.21
30	0.17

6.5.5 Heatsink Clips

The retention mechanism in this reference solution includes two different types of clips, one is ramp clip and the other is wire clip. Each end of the wire clip is attached to the ramp clip which in turn attaches themselves to anchors to fasten the overall heatsink assembly to the motherboard. See [Appendix B](#) for a mechanical drawing of the clip.

Figure 6-6. Plastic Wave Soldering Heatsink Extrusion Profile


6.5.6 Clip Retention Anchors

For Intel 3000 and 3010 chipset-based platforms that have very limited board space, a clip retention anchor has been developed to minimize the impact of clip retention on the board. It is based on a standard two-pin jumper and is soldered to the board like any common through-hole header. A new anchor design is available with 45° bent leads to increase the anchor attach reliability over time. See [Appendix A](#) for the part number and supplier information.



6.6 Reliability Guidelines

Each motherboard, heatsink and attach combination may vary the mechanical loading of the component. Based on the end user environment, the user should define the appropriate reliability test criteria and carefully evaluate the completed assembly prior to use in high volume. Some general recommendations are shown in [Table B-1](#).

Table 6-2. Reliability Guidelines

Test ⁽¹⁾	Requirement	Pass/Fail Criteria ⁽²⁾
Mechanical Shock	50 g, board level, 11 msec, 3 shocks/axis	Visual Check and Electrical Functional Test
Random Vibration	7.3 g, board level, 45 min/axis, 50 Hz to 2000 Hz	Visual Check and Electrical Functional Test
Temperature Life	85 °C, 2000 hours total, checkpoints at 168, 500, 1000, and 2000 hours	Visual Check
Thermal Cycling	–5 °C to +70 °C, 500 cycles	Visual Check
Humidity	85% relative humidity, 55 °C, 1000 hours	Visual Check

Notes:

1. It is recommended that the above tests be performed on a sample size of at least twelve assemblies from three lots of material.
2. Additional pass/fail criteria may be added at the discretion of the user.







A Thermal Solution Component Suppliers

A.1 Plastic Wave Soldering Heatsink Thermal Solution

Part	Intel Part Number	Supplier (Part Number)	Contact Information
Heatsink Assembly includes: <ul style="list-style-type: none"> Unidirectional Pin-Fin Heatsink Thermal Interface Material Ramp Clip Wire Clip 	C92237-001	CCI	Monica Chih (Taiwan) 866-2-29952666, x131 monica_chih@ccic.com.tw Harry Lin (CCI/ACK-USA) 714-739-5797 hlinack@aol.com
Unidirectional Pin-Fin Heatsink (42.30 x 42.30 x 29.0 mm)	C92139-001	CCI	Monica Chih (Taiwan) 866-2-29952666, x131 monica_chih@ccic.com.tw Harry Lin (CCI/ACK-USA) 714-739-5797 hlinack@aol.com
Thermal Interface (T710)	-	Chomerics	Todd Sousa (USA) 360-606-8171 tsousa@parker.com
Heatsink Ramp Clip	C92140-001	CCI	Monica Chih (Taiwan) 866-2-29952666, x131 monica_chih@ccic.com.tw Harry Lin (CCI/ACK-USA) 714-739-5797 hlinack@aol.com
Heatsink Wire Clip	C85373-001	CCI	Monica Chih (Taiwan) 866-2-29952666, x131 monica_chih@ccic.com.tw Harry Lin (CCI/ACK-USA) 714-739-5797 hlinack@aol.com
Solder-Down Anchor	C85376-001	Wieson	Rick Lin Deputy Manager/Project Sales Department Add.: 7F, No. 276, Section 1, Tatung Road, Hsichih City, Taipei Hsien, Taiwan Tel: 886-2-2647-1896 ext. 6342 Mobile: 886-955644008 Email: rick@wieson.com Website: www.wieson.com

Note: The enabled components may not be currently available from all suppliers. Contact the supplier directly to verify time of component availability.





B Mechanical Drawings

Table B-1 Mechanical Drawing List lists the mechanical drawings included in this appendix.

Table B-1. Mechanical Drawing List

Drawing Description	Figure Number
Plastic Wave Soldering Heatsink Assembly Drawing	Figure B-1
Plastic Wave Soldering Heatsink Drawing (1 of 2)	Figure B-2
Plastic Wave Soldering Heatsink Drawing (2 of 2)	Figure B-3
Plastic Wave Soldering Heatsink Ramp Clip Drawing (1 of 2)	Figure B-4
Plastic Wave Soldering Heatsink Ramp Clip Drawing (2 of 2)	Figure B-5
Plastic Wave Soldering Heatsink Wire Clip Drawing	Figure B-6
Plastic Wave Soldering Heatsink Solder-down Anchor Drawing	Figure B-7

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REVISION HISTORY			
ZONE	REV	DESCRIPTION	DATE
2	B	CHANGE TIM FROM PMS45 TO T710	12.23.84
1	A	INITIAL RELEASE	10.13.84

PARTS LIST	
QTY	ITEM NO
1	5
2	4
1	3
4	2
1	1
TOP	C92237-001
DESCRIPTION	
MCH HEATSINK ASSY	

DESIGNED BY DATE		DEPARTMENT	
YINJONG WEI	10.12.84	END	DATE
DRAWN BY		TITLE	
YINJONG WEI		MCH HEATSINK ASSY	
CHECKED BY DATE		DATE	
ROBIN TSAI		10.13.84	
APPROVED BY DATE		DATE	
MATERIAL		FINISH	
SEE NOTES		SEE NOTES	

MCH HEATSINK ASSY	
SIZE	REV
C92237	B
SCALE: 1	
DO NOT SCALE DRAWING SHEET 1 OF 1	

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[illegible]

Figure B-4. Plastic Wave Soldering Heatsink Ramp Clip Drawing (1 of 2)

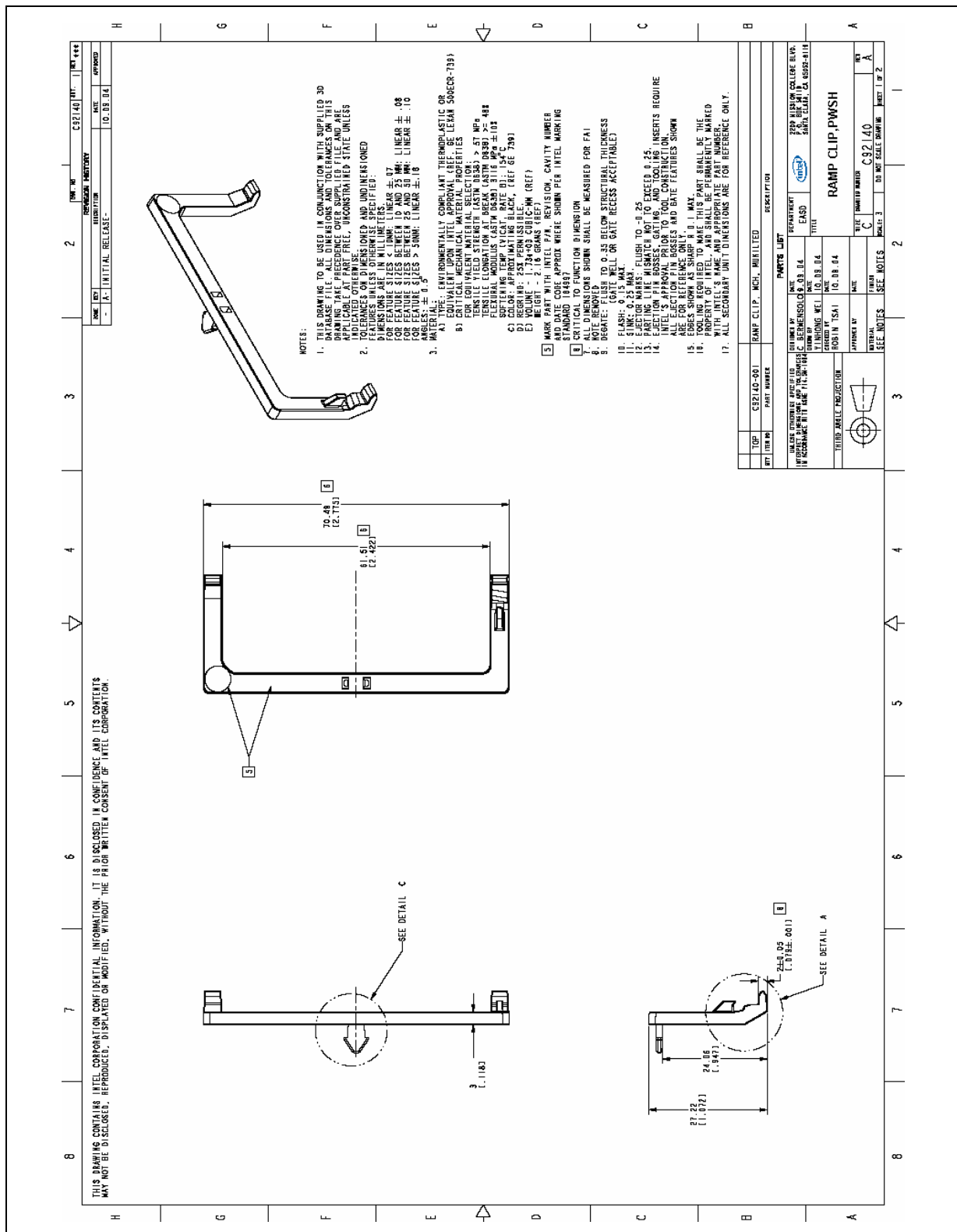
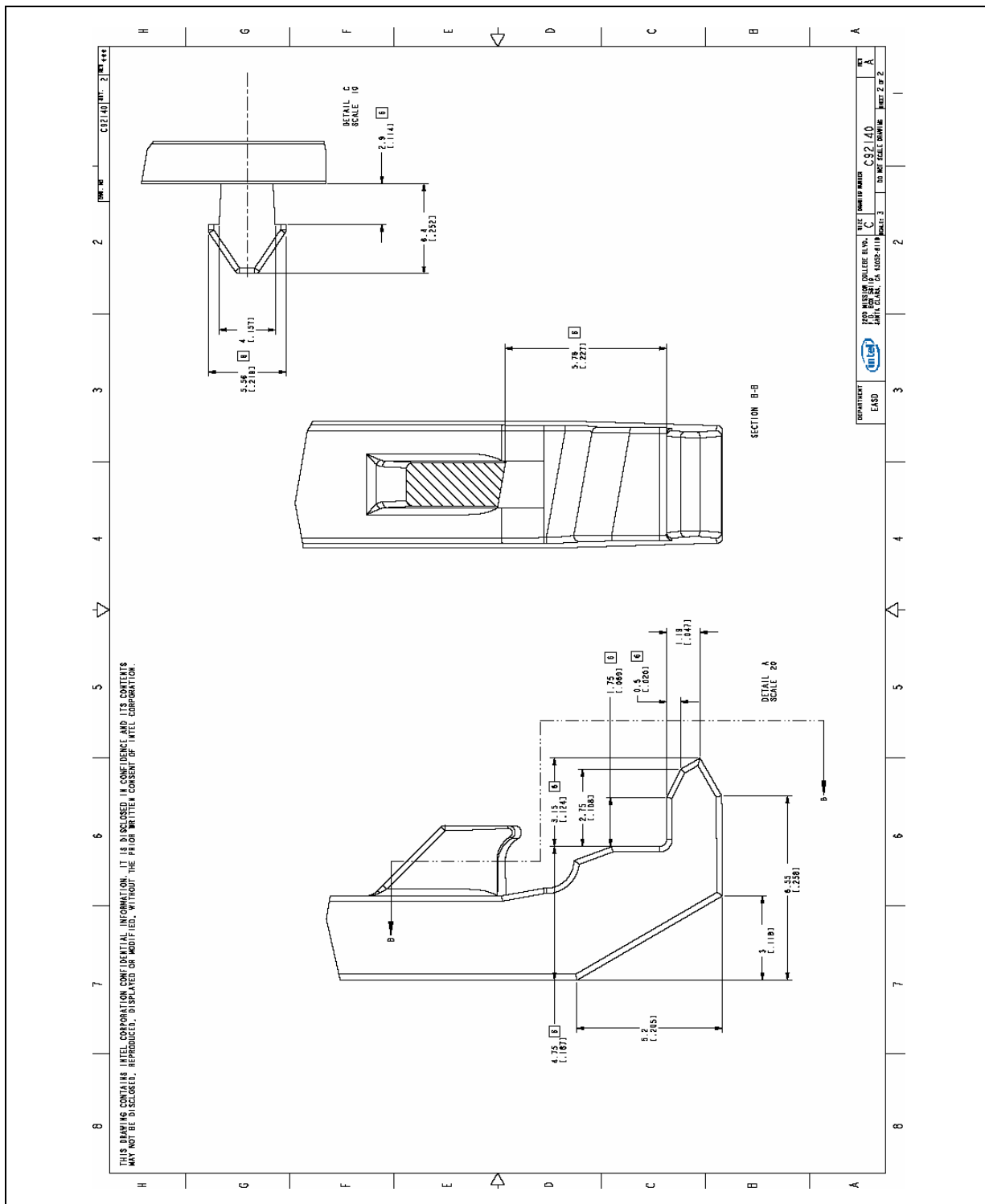


Figure B-5. Plastic Wave Soldering Heatsink Ramp Clip Drawing (2 of 2)



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